

**Flat plate antenna with a rotating field, comprising a central loop and eccentric loops, and system for identification by radiofrequency**

**5      Background of the invention**

The invention relates to a substantially flat rotating field antenna comprising a central loop and coplanar eccentric loops.

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**State of the art**

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Radiofrequency identification systems enable contact-free data exchange by inductive coupling between a read unit and objects to be identified, conventionally tags. The energy necessary for the tags is taken from the electromagnetic field.

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The read unit emits an electromagnetic field in an exchange zone limited by the emitting power of the read unit. The data are transmitted between the read unit and the tag by modulation of the electromagnetic field. Due to the shape of the field lines, data exchange can only be performed for particular relative positions of the tags with respect to an antenna of the read unit.

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A read unit equipped with an antenna having a single flat loop plane enables data to be transferred in the centre of the antenna to a correctly directed tag, in particular if it is parallel to the plane of the loop of the antenna. The inductive coupling between the antenna and a tag positioned in a plane orthogonal to the plane of the loop is weaker and often insufficient to detect the tag. This is due to the fact that, in the centre of the antenna, the magnetic field lines are

perpendicular to the plane of the loop and, the flux flowing through the tag is therefore minimum when the tag is arranged in a plane perpendicular to the plane of the loop. On the contrary, when the tag is parallel to the plane of the loop, the flux flowing through the tag is maximum.

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Moreover, according to international radiofrequency radiation emission standards, the emission power is limited by the field level at a distance of 10 m from the antenna, which limits the possibility of compensating an angle of incline of the tag by a more intense field.

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United States Patent US6166706 describes a substantially flat rotating field antenna comprising a central loop and two coplanar eccentric loops. The two eccentric loops are connected and supplied in parallel. The central antenna is supplied, in phase quadrature, by inductive coupling with the eccentric loops. The antenna thus produces a rotating field in a plane orthogonal to the plane of the antenna. A tag located in this plane cannot be detected.

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Moreover, other types of antennas are described in the documents US5005001 and US6650213:

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The document US5005001 describes a system of antennas comprising rectangular first coils arranged facing one another so as to form a portal, to generate a non-rotating magnetic field. In addition, the system comprises means for creating a rotating magnetic field using two pairs of additional coils respectively arranged in the same plane as the first coils, inside the latter. The two additional coils of each pair are connected in such a way that the same current flows through them with a phase difference of  $180^\circ$ . Thus, the document US5005001 describes two substantially flat rotating field antennas arranged facing one another. Each antenna comprises a peripheral loop and two coplanar internal loops.

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The document US6650213 describes an antenna formed by a set of four adjacent coplanar coils. A magnetic field control element enables the polarity and phase of the magnetic field generated by each coil to be controlled, so as to modify the direction of the magnetic field near the set of coils to guide a spherical semi-conducting element in the direction of the set of coils. Two adjacent coils are positively polarized and the other two coils are negatively polarized.

Whatever the shape of the antennas or whatever the direction of the field created by the antennas, perpendicular to the antenna plane for US5005001 or parallel to the antenna plane for US6650213, a dead zone of the field always remains, perpendicular to the electric conductors that form the antenna.

### **Object of the invention**

It is one object of the invention to remedy these shortcomings and, in particular, to provide a flat antenna enabling a radiofrequency identification tag having any orientation to be detected, while limiting the field level at a distance of 10 m from the antenna.

According to the invention, this object is achieved by the appended claims and, in particular, by the fact that, the central loop creating a magnetic field essentially perpendicular to the antenna, the antenna comprises four adjacent coplanar eccentric loops, supplied in such a way as to create a rotating field predominantly in a plane parallel to the plane of the antenna, the centres of gravity of the eccentric loops being arranged substantially on the periphery of the central loop.

It is a further object of the invention to provide a system for identification by radiofrequency comprising a rotating field antenna and a radiofrequency generator comprising first and second outputs alternately supplying first and second excitation signals respectively to the central loop and to the eccentric loops.

### **Brief description of the drawings**

Other advantages and features will become more clearly apparent from the following description of particular embodiments of the invention given as non-restrictive examples only and represented in the accompanying drawings, in which:

Figures 1 and 2 schematically illustrate two particular embodiments of an antenna according to the invention.

Figure 3 represents a particular embodiment of two eccentric loops associated with an antenna according to the invention.

Figure 4 represents a particular embodiment of an identification system according to the invention.

Figure 5 schematically represents a particular embodiment of phase shifting means of an identification system according to the invention.

### **Description of particular embodiments**

In both figures 1 and 2, a rotating field antenna comprises a substantially rectangular central loop 1 and four adjacent coplanar eccentric loops 2 (2a, 2b, 2c, 2d). The eccentric loops 2 and the central loop 1 are essentially arranged in

the same plane. The antenna is then substantially flat. As represented in figures 1 and 2, the four eccentric loops (2) can be arranged symmetrically with respect to the centre of the central loop.

5 The four eccentric loops 2 can be supplied in such a way that two adjacent eccentric loops 2 have a phase difference of  $90^\circ$  and two non-adjacent eccentric loops 2 therefore have a phase difference of  $180^\circ$ . In this way, the superposed fields of the four eccentric loops 2 create a rotating magnetic field mainly in a plane parallel to the plane of the antenna.

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The central loop 1, independently from the eccentric loops 2, creates a magnetic field that is essentially perpendicular to the antenna, presenting a maximum in a central zone 3a represented by a broken line, extending in volume perpendicularly to the plane of the antenna.

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As represented in figures 1 and 2, the centres of gravity G (Ga, Gb, Gc, Gd) of the eccentric loops 2 are located substantially on the periphery of the central loop 1. In this way, the rotating field in the plane of the antenna, created by the eccentric loops, has a maximum in the central zone 3a.

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Analysis of the magnetic fields created by the eccentric loops 2 on the one hand, and by the central loop 1 on the other hand, shows that the distribution of the fields is substantially complementary in the central zone 3a and in a peripheral zone 3b of the central zone 3a. Indeed, as indicated above, the central loop 1  
25 creates a magnetic field component perpendicular to the plane of the antenna, in the central zone 3a, whereas the eccentric loops 2 create a rotating component in the plane of the antenna, in the central zone 3a. Inversely, in the peripheral zone 3b of the central zone 3a, the central loop 1 creates magnetic field

components oriented in the plane of the antenna, whereas the eccentric loops 2 create a component perpendicular to the plane of the antenna.

The antenna can therefore detect a tag positioned in any direction and located in the exchange zone formed by the central zone 3a and the peripheral zone 3b. The magnetic field components perpendicular to the plane of the antenna enable tags located in a plane parallel to the antenna to be detected, whereas the magnetic field components arranged in the plane of the antenna enable tags located in a plane orthogonal to the plane of the antenna to be detected.

In figure 1, the eccentric loops 2 are substantially rectangular. The shape of the loops constituting the antenna influences the magnetic field distribution. To improve detection of tags located orthogonally to the plane of the antenna, a triangular shape of the eccentric loops 2 is more suitable than a rectangular or square shape. Indeed, for the same surface, a triangular loop creates more horizontal field lines than a square loop. Thus, in the preferred embodiment illustrated in figure 2, the eccentric loops 2 are substantially triangular, an apex of each triangle being located in the central zone 3a of the antenna. However, other shapes can be envisaged, such as for example a circular central loop 1 and eccentric loops 2 in the shape of a sector of a circle.

In the embodiments represented in figures 1 and 2, the eccentric loops 2 are associated in pairs of non-adjacent loops (their connection is represented schematically by a single line 4), so as to generate electromagnetic fields of opposite phases in said pair. For example, as represented in figure 3, two eccentric loops 2a and 2c are formed by a conductor 5 arranged in the shape of an 8. The conductor 5 is supplied by terminals 6 common to the two loops 2a and 2c. An electric current  $I$  thus flows first through the first loop 2a of the conductor 5 in a first direction and then automatically through the second loop 2c

of the conductor 5 in a second direction, opposite to the first. The two loops 2a and 2c are then connected in such a way that the same current flows through them in opposite trigonometric directions. The set of four eccentric loops 2 can thus be formed by an assembly of two conductors 5 superposed substantially in the same plane, with a 90° offset in this plane. The two conductors 5 do however have to be positioned at a minimum distance to limit capacitive couplings. In addition, locating the two conductors 5 at a distance from one another enables the volume of the rotating field to be increased.

It is particularly interesting to achieve a symmetric antenna, i.e. with eccentric loops 2 that are symmetric with respect to the centre of the central antenna 1. Moreover, this symmetry plus the fact that the fields of the eccentric loops 2 are in phase opposition two by two, means that the total field at 10m is practically zero. The standard characterized by a field at 10m lower than a set threshold can be easily respected even with powers of the eccentric loops 2 that are higher than in the prior art.

In figure 4, a radiofrequency identification system comprises a radiofrequency generator 7, in addition to the rotating field antenna. The generator 7 comprises a first output 8 and a second output 9 alternately supplying first S1 and second S2 excitation signals, respectively to the central loop 1 and to the eccentric loops 2. In this way, the rotating field created by the eccentric loops 2 does not interfere with the field created by the central loop 1. Simultaneous supply of the central loop 1 and of the eccentric loops 2 can in fact, by destructive interference, create magnetic field minima in the central zone 3a and the peripheral zone 3b.

However, simultaneous supply of the central loop 1 and the eccentric loops 2 also creates maxima. It can therefore be of interest to supply the different central

loops 1 and eccentric loops 2 according to activation cycles successively, for example, the central loop 1, then the eccentric loops 2, then all the loops, etc...

To take advantage of the field maxima described above when the central loop 1 and the coplanar eccentric loops 2 are operating simultaneously, the fields can be made to rotate so that they scan the whole exchange zone. This can, for example, be achieved if the first S1 and second S2 excitation signals have slightly different frequencies. For example, for radiofrequency identification operation at 13.56 MHz, it is theoretically possible to have a frequency offset of 7kHz. Practically, taking account of the noise and the margins taken for satisfactory operation, this offset is reduced to 1kHz or 2kHz. This solution is therefore preferably accompanied by powerful software processing on account of the time the tags are present in the field, typically about a few milliseconds.

As represented in figure 5, the phase quadrature phase difference of the adjacent eccentric loops 2d and 2c can be performed by a phase shifter power divider 10 respectively supplying signals S3 and S4 in phase quadrature on its two outputs 11 and 12. An input 13 of the power divider 10 is preferably connected to the second output 9 of the radiofrequency generator 7. The eccentric loops 2 represented in figure 5 are also associated in pairs (2a and 2c, 2b and 2d). In this way, the two loops of a pair can, as represented in figure 3, be connected to one another and to common terminals 6, so that a single current I flows through these loops in opposite trigonometric directions. The signals S3 and S4 are applied respectively to the common terminals 6 of each of the two pairs. In this way, each eccentric loop 2 is supplied in phase quadrature with respect to its two adjacent loops.

The dimensions of the antenna depend on the application for which the latter is intended. For an application in a close field identification system, a surface of



10cmx15cm is sufficient and enables a three-dimensional magnetic field of more than 5A/m to be generated in the central zone 3a and the peripheral zone 3b in the plane of the antenna, while respecting international radiofrequency radiation emission standards.

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For a mobile equipment recharging application, for example for recharging a mobile telephone or a walkman, a larger surface of about 25cmx25cm is appropriate. For example, a mobile telephone equipped with an electromagnetic induction recharge module can be recharged by placing it on the antenna, whatever its orientation.

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For identification in a farther field, for example about 1m<sup>3</sup>, a surface of 1m<sup>2</sup> is necessary.

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